STEPHEN AUSMUS (K10595-1)

Improving On a Time-Tested Technique

Microbiologist Patricia Millner and technician Michael Bzdil collect compost samples and gather data on temperature and moisture content. The samples will be analyzed in the lab for pathogen content.

Composting, essentially a rapid, self-heating process by which organic material is decomposed and stabilized, was practiced by ancient Egyptians, Greeks, and Romans and is even mentioned in religious texts. During the past 20 years, this time-honored practice has developed into a robust waste-management technology that generates valuable organic soil amendments.

ARS microbiologist Patricia Millner, of the Environmental Microbial Safety Laboratory in Beltsville, Maryland, is working to make composting more feasible for animal producers, who face a daily challenge: manure management. Dairy cows produce about 80 pounds of manure every day, or 4 tons for every 100 cows. This can quickly become a large waste-management challenge in operations housing several hundred cows. When many operations are located in small areas, the materials-handling requirements are intensified.

Composting is one of several technologies used to treat animal manure, sewage sludge, and other organic residuals, which may contain pathogens or parasites of public health concern. In any manure slurry system, solids can be composted. Liquids can be further processed to stabilize nitrogen and phosphorus in soluble forms compatible with current nutrient-management requirements.

Biological treatment technologies may be either aerobic or anaerobic. Aerobic systems use oxygen, but anaerobic ones don't. Both may use heat to fuel the reactions that break down organic matter in manure. In composting, heat is generated by microbes that digest organic matter.

Millner has been conducting research on what she calls hybrid composting systems. These systems not only reduce numbers of pathogens like *Escherichia coli* O157:H7, *Salmonellae*, and *Listeria*, but they also reduce excess available phosphorus and keep the ratio of nitrogen to phosphorus within a range acceptable for use in areas that have nutrient-management plans. Her approach means that composting can address nutrient, pathogen, and odor concerns all at the same time.

Creating Quality Compost

Millner and her colleagues conduct their research on manure from the Beltsville facility's 200-head research dairy herd and various other research animals, greenhouse and landscape trimmings, old animal feed and bedding, other organic matter, and water. The compost mixture is formed into elongated piles, called windrows. Each windrow is 150 feet long, 8 feet wide, and 4.5 feet high. The initial carbon-to-nitrogen ratio of the mixture should be about 30 to 1, and the water content should be between 40 percent and 60 percent. A loose, porous texture must be achieved so that air can move in and out of the mixture. Millner's hybrid composting processes involve adding various inorganic byproducts containing aluminum, calcium, iron, and other minerals, as well as acid solutions.

Within a day or two, heat generated by microbes begins to collect in the core of the windrow—known as the hot zone. Temperature and oxygen content are monitored, and the mixture is turned to aerate it and stimulate the aerobic microbes that are rapidly eating the organic matter. This very active phase—in which temperatures can reach 150˚F—lasts 3 to 4 weeks. Then, as the microbes gradually deplete the food sources, their metabolic activity declines and so does the temperature of the mix.

Other methods of treating manure include heat drying, air drying, pasteurization, or lagooning. Each method can accomplish the task, but all may require more time, external inputs, or money than composting. Composting seems to offer the most economically efficient method for animal-feeding operations to treat manure solids before land application.

The technique offers another advantage. Animal production facilities often smell bad because of manure stockpiles. But during the composting process, odorous compounds are contained in the pile, decomposed by the microbes, and ultimately replaced by more pleasant earthy ones. Chemist Laura McConnell of the Environmental Quality Laboratory, also in Beltsville, has been collaborating with Millner to determine which odor-producing compounds are present at the start, at what point they disappear, and how field personnel can monitor them.

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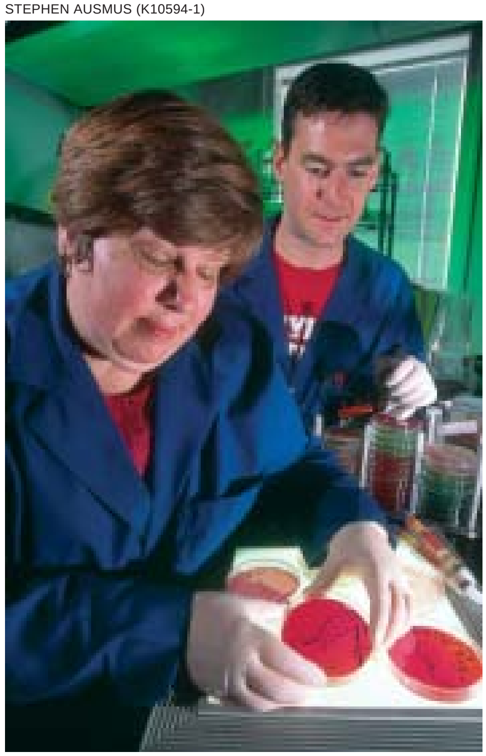

Patricia Millner and research assistant David Ingram examine bacterial colonies on nutrient media to detect and count various pathogens in manure samples before composting. Similar examinations are later conducted on finished compost to ensure that pathogens have been killed.

Controlling Pathogens and Nutrients

Composting can effectively reduce pathogens and parasites commonly found in manure as well as those that have mutated into different strains with new abilities, like surviving in acidic environments. Millner estimates that once certain time-and-temperature criteria are achieved, *E. coli* and *Salmonellae* in the compost are nearly eliminated (99.9999 percent kill rate).

In a field that receives manure compost, "this reduces the numbers of pathogens that would find their way onto produce and into runoff after a rain," says Millner. It also stabilizes the nutrient content of the compost so that bacteria cannot regrow; the nutrients they require are depleted. Intense microbial competition further retards regrowth of the pathogenic bacteria in the final product.

The pathogen-reduction criteria include a temperature of at least 131˚F for 3 consecutive days in an aerated pile or 131˚F for 2 weeks in the hot zones of a windrow pile with five turnings. This process can kill nearly all pathogenic microbes and still maintain populations of beneficial ones.

The demand for animal manure is projected to increase. As organic vegetables and fruits gain popularity, more growers value its benefits to soil quality and to the environment. Although in many states untreated manure can be applied to farm fields, this practice can introduce pathogens and parasites into soils and possible runoff or irrigation water. Various state regulations must be considered before agricultural compost can be marketed and sold.

"Agriculture is a farm-to-plate continuum, and we want to make it as safe as possible," says Millner. "It is important to make compost usable to agriculture and horticulture to prevent water and food contamination." And this is where treatment of manure comes into play.

Composting also results in stabilization of nitrogen in organic form for use in soils. Compost may even be tailor-made to reduce phosphorus availability and to remediate nutrient-deficient soils. Like pathogens, excess unused nutrients make their way in runoff from fields into surface water. "Nutrient stabilization in composted manure allows soil microbes and plants to use nutrients in a slow-release and beneficial manner," says Millner. "Compost may even help reduce demand for nitrogen in certain crops."

Even though the basic technology may be ancient, composting still has much to offer the world of modern agriculture.—By **Sharon Durham,** ARS.

This research is part of Manure and Byproduct Utilization, an ARS National Program (#206) described on the World Wide Web at www.nps.ars.usda.gov.

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